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ECONOMIC ORNITHOLOGY AND THE CORRELATION OF LABORATORY AND FIELD METHODS

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Introduction

Economic ornithology in its broadest sense includes all relations of birds that have any bearing upon the material welfare of man. Much has been published on the direct and indirect uses made of birds and their products, and here special reference may be made to such works as T. S. Palmer's "A Review of Economic Ornithology in the United States" (9) and Junius Henderson's "The Practical Value of Birds." (3)

The present paper is largely restricted to an account of methods of food habits research as carried on both in the laboratory and in the field. The broad objective of this phase of the study of economic ornithology is to determine the relationship that the various bird species bear to man because of their food and feeding habits, particularly in their relationship to agriculture, horticulture, and forestry. With few exceptions the most important relationship that wild birds have to man comes from their food habits. The farmer is concerned, for example, when birds are in his orchard or among his crops, whether they are eating produce or are feeding on destructive insects or obnoxious weed seeds. There are scores of species of birds and other animals that for one reason or another frequent orchards, vineyards, and fields, and the only way to ascertain precisely their relation to agriculture is by scientific study of their food habits.

Examples of species that have been condemned and praised by different groups of people are found in the case of the snapping turtle, the blacksnake, the squirrel, the fox, the bluejay, the sparrow hawk, and the robin. Should these species be encouraged or controlled? Whether they are beneficial or harmful from the economic viewpoint is largely determined by their food habits. The first requisite in game or in wildlife management generally is a determination of the food habits of the bird or other animal considered. Without this information, their increase or even their perpetuation may be difficult if not impossible. Without it, plantings or liberation of new stock is useless. It is only through possession and utilization of adequate information on food habits that we can intelligently formulate a public policy toward wildlife.

In this study, as in the search for all truth, the scientific observer gathers reliable data from every available source. In the realm of economic biology, and particularly in economic ornithology, the accumulated experience of many capable workers in the Biological Survey for more than half a century gives convincing proof that this science, if it is to serve its greatest purpose, must draw freely upon both laboratory and field research. Each approach supplements the other, and each renders indispensable aid in the rational interpretation of the other. Either method alone has its limitations therefore, and where one is employed to the exclusion of the other, an unbalanced and often an untenable conclusion may result.

For more than three quarters of a century stomach examination has served as the basis for most of the advance in the science of economic ornithology. This has in most instances, however, been well supplemented by and correlated with extended field research. The first official Federal recognition of this work was authorized in 1885 when Congress created in the Division of Entomology a Section of Economic Ornithology (which later developed into the Bureau of Biological Survey), "for the promotion of economic ornithology, or the study of interrelation of birds and agriculture, an investigation of the food, habits, and migration in relation to both insects and plants and publishing reports thereon." A summary of fifty years of economic ornithology, by McAtee (6), was published by the American Ornithologists' Union in 1933.

Laboratory Research

While experience has taught us that, in dealing with the subject as a whole, either the field or the laboratory method is inadequate used alone, there are numerous instances where one or the other of the two methods can be used to the greatest advantage; in most cases, however, both methods must be employed if a true and complete picture is to be obtained. Kalmbach (4) has offered convincing examples of numerous problems best answered by field study. It should be pointed out also that there are important problems in economic ornithology that can best be determined by placing emphasis on laboratory examination of stomachs. In these instances, field research serves to supplement the laboratory method.

A recent careful study of an important upland game species may well serve as an illustration. The observer, a well-trained field technician, made intensive field studies of the species in question over a period of two years, and since he had grown up in an area where the bird was common, he was intimately acquainted with it. As a part of this study considerably more than two hundred typically well-filled crops and gizzards of birds were collected and submitted to the Biological Survey for laboratory analysis. The specimens taken were well distributed over the region and represented all seasons of the year. In transmitting the stomachs the field worker listed the principal foods as determined by his studies alone. The comparison of his results based on years of observation with those derived from laboratory analysis is of interest. Study of the actual food taken, as determined by laboratory examination, showed that five of the plant foods that had been considered of greatest importance by the field observer were of only minor value. Six of the items found by laboratory analysis to be of great value were recognized by the field observer though he failed to note eight of the principal foods found by stomach analysis. Of 22 foods classed in the laboratory as being of moderate value, only 5 were detected by the field observer. He also noted only 38 foods, while the laboratory examiner listed 460 different kinds. The results may be summarized as follows:

Foods considered important by field observer, but not important in stomach analysis.	5
Foods considered important by field observer and important in stomach analysis.	6
Foods not considered important by field observer but important in stomach analysis.	8
Foods not noted by observer but occasional in stomach analysis.	17
Foods noted by observer and occasional in stomach analysis.	5

Total food items recorded in the field, 38; in the laboratory, 460.

From these results it will be seen that field observations alone would have been much less than 50 percent accurate in appraising food values. Such a disparity in results is indeed worthy of serious consideration when upland game management is being considered. The economics of the problem should be obvious when it is realized that game bird hunting is becoming increasingly more dependent upon game management. Food habits research is fundamental to the proper management and conservation of game and other wildlife resources. Many thousands of dollars have been wasted in the past in attempts of local and State organizations to increase the stocks of game when they did not have adequate knowledge of the food and other requirements of the species concerned. McAtee (7) has very ably presented a summary of the importance of economic ornithology and has recorded the views of some of the best authorities on game management in his statement presented before the Subcommittee of the House Committee on Appropriations in Charge of the Agricultural Department Bill for 1936.

The need for stomach examination is even more apparent when devising a management program for aquatic game birds, which must include a study of their food requirements and food habits. Waterfowl feed largely with their heads or entire bodies submerged; therefore, it is impossible to determine accurately from field observation alone what the birds are feeding on or in what proportion various submerged foods are chosen. To find waterfowl feeding among a given plant species is not necessarily adequate proof that the birds may be using that particular plant as food. The fallibility of field observation as a means of determining what birds are eating has been demonstrated innumerable times to research workers in economic ornithology.

A recent example along this line is but one of many that could be cited. A South Carolina duck club manager wrote the Biological Survey that his birds were feeding largely on alligator grass (Alternanthera philoxeroides), the first intimation to the Bureau that it was an important food for wildfowl. The game technician of the club had urged that the Biological Survey recommend the establishment of this plant species, which in reality is a serious menace to valuable duck foods in many southern areas. After considerable insistence the gentleman was issued a special permit to take six of the birds thought to be feeding on the plant. Laboratory examination failed to show the slightest trace of the alligator grass in a single stomach, the principal foods consisting of diatoms, and seeds of bulrush, switchgrass, and wild millet.

In connection with the numerous complaints of bird depredations received, some of the problems entailed are more accurately and more expeditiously handled by field investigation, while the treatment of others must be based largely on laboratory analysis. In those cases where circumstances call for the identification of food items, the laboratory method of stomach examination is almost the only approach. Much practical advantage to wildlife has resulted from a policy of ascertaining facts before determining a course of action, such as issuing or refusing to issue permits for control. The study of food habits, primarily through laboratory stomach examination, has formed the factual basis upon which has been built the American code of protective laws and regulations for birds, which ornithologists agree is without doubt the most effective known. This study in a large measure has been the basis also for the wide-spread educational interest in birds and bird protection.

Where bird depredations are reported (not infrequently for ulterior purposes), direct stomach examination is usually the best method to follow. Cases of serious depredation may be charged to a conspicuous species of bird, while the real cause of loss to crops or trees may be traceable to an insect or some other pest. The true identity of the destructive organism in such cases is usually promptly indicated by stomach examination.

To cite a specific case of alleged depredation: A certain State was demanding that its shell fishermen be issued permits to destroy eider ducks that were supposed to be subsisting on commercial shellfish. While the ducks were known to be feeding over planted scallop and oyster beds, stomach examination of a representative series showed that the birds had been feeding almost exclusively upon species of mollusks of no commercial value.

While laboratory stomach analyses have substantiated many claims of depredations by fish-eating birds, they have demonstrated even more claims to have been unfounded. A typical example of unsubstantiated charges originated among a group of residents of one of the southern States after the Migratory Bird Treaty Act was passed. It was claimed that the yellow-crowned night heron was a menace to both the frogging industry and game fishing interests. The young of these herons, known locally as "gros-becs" had long been used by this group of people as a choice article of food. The destructive and unsportsmanlike practice of shooting juveniles, or otherwise killing the young on the nest, was certain ultimately to jeopardize the species. An investigation was made and a series of 112 stomachs of the yellow-crowned night heron was collected in the section from which the complaint had originated, and careful and detailed laboratory stomach examination was made of each. Seven stomachs, because of being nearly empty, were excluded from final computation. All but one of the remaining 105 contained crawfish (Cambarus sp.), which in 99 made up the entire stomach contents. Not a single trace of frog or fish could be found in any of the series. In this investigation, field work gave no evidence that the birds were destructive to human interests, yet neither conclusive nor convincing proof exonerating them was obtained until laboratory stomach examinations were completed.

During a cooperative quail investigation undertaken by the Biological Survey, the marsh hawk was suspected of being an enemy of quail on southern plantations. Large numbers of these raptors winter in the South, and naturally the question of their relationship to quail was raised by investigators interested in learning more about the factors affecting the welfare of these game birds. Field observations could not certainly establish the bird's status. Stomachs were not available in sufficient quantity to tell the whole story, but pellets of the species could be gathered in good quantity, and some 1,100 were carefully analyzed to ascertain in detail just what constituted the diet. The results disclosed the presence of quail in 4 instances and cotton rats in 925. This information indicated clearly that the marsh hawk renders a distinct service to quail on areas where rodent prey is abundant.

As a means of developing a general background for proper appraisal of average food tendencies and general economic status of most birds or other animals, stomach analyses of both extensive and representative material are fundamental. The skill required in the examination of stomach contents comes only as a result of thorough training in the art of close observation and through experience in associating certain small diagnostic fragments with a definite species. Recently the stomach content of a mammal was sent to the Biological Survey to verify the identification of an item thought to represent the entire food. This was submitted by an expert on field methods, who also was a careful wildlife research worker. Separation of the material in the laboratory revealed that the item in question actually made up only half of the total bulk; some five additional items were found to make up the remainder. Proper equipment, including extensive reference collections, and trained workers are essential for accuracy and completeness in food habits investigations. Without this accuracy there can be no reliable basis for improvement of wildlife food resources.

Field Research

Without correlation of adequate field research, many of the data obtained by laboratory studies could not be properly interpreted. In many cases, stomach analyses are almost meaningless without knowledge of field conditions and of the circumstances surrounding the collection of stomach material. The presence of grain or fruit in a bird's stomach, for example, may represent a depredation, waste material, garbage, or the harvest of a wild, volunteer, or abandoned crop, or it may indicate a meal provided by a bird-lover. In the case of fruit eaten by the starling, Kalmbach (4) found from field study that damage to late fruit is consistently greater in old, poorly kept orchards than in the young, thrifty ones that supply the bulk of the higher grade, marketable fruit. The remains of game or livestock in a predator's stomach may represent either predation or the taking of carrion. The presence of a small bird in the stomach of a crow or a fox may represent a case of vandalism or the carrion-feeding habit. Knowledge of the detestable habit of the magpie in attacking and feeding on young, sickly, or freshly-branded livestock could not be gained by stomach examination. The appraisal of the extent of such depredations is obtainable only from actual observation in the field. Even though the trained laboratory worker can often determine with reasonable accuracy the presence of carrion or waste material by various tests, the size of the animal eaten, the presence of certain insects, the nature of the stomach contents, the habits of the species in question, or other circumstances, many cases are questionable without field data. Even though the experienced investigator realizes that in food habits work the first step necessary is to identify the food items accurately, he soon discovers that in many instances correct interpretation of the facts observable is of greater significance than identification of the items themselves.

The character or quality of some of the food of certain species is not amenable to accurate laboratory analysis. The information on the food and feeding habits of sapsuckers, hummingbirds, porcupines, and a number of field rodents is woefully incomplete without field study, as these creatures feed on liquids or plant fiber that is so finely comminuted that laboratory identification is difficult and often impossible.

Field work is an absolute necessity to enable the economic ornithologist to interpret the results of stomach analysis and to convert abstract percentages of bird food items into terms of agricultural or horticultural economics. Numerous examples of the necessity of field work that have come under personal observation of economic ornithologists are graphically portrayed by E. R. Kalmbach, in his Field Observations in Economic Ornithology (4). One example, which treats of depredations by ducks in California (4), may be quoted:

". . . On the basis of about 150 stomachs of four species of ducks it revealed that pintails ate a greater percentage of barley (43 percent) than the other ducks, a fact quite generally recognized by local sportsmen and farmers. It also verified the generally accepted belief that wigeons ate more sprouting alfalfa than any of the other species. It also showed that the little green-winged teal ate less barley (22.0 percent) than the wigeon (24.5 percent).

"What, however, did field studies show? In the first place, they told something of the extent of the devastation wrought. They shed light on the acreage of damaged fields and the fact that, in addition to the immediate injury, the ducks often so puddled and de-aerated the fine silt of the grainfields that an unfavorable soil condition was created that lasted for several seasons. They revealed that the 30 percent of young alfalfa eaten by the wigeon meant at times a severe economic loss in uprooted plants. They disclosed the fact that the wigeon, a more abundant and more voracious feeder, far out-stripped the diminutive teal as a destroyer of barley seed, although stomach examination showed only slight disparity between the proportions of barley found in each. And back of all that, they told the vital story that so severe had the damage been in some winters that illegal shooting to protect crops was frequently resorted to; that honest efforts to protect grain were being discredited by abuses on the part of hunters who offered 'their services in the cause of crop protection'; that game law administration became a real problem; and that the whole fabric of the game protective movement in this locality was jeopardized largely because of a lack of understanding of what ducks can sometimes do. All in all, in the study of this local but vital problem of economic ornithology, field studies played a decidedly important role."

Knowledge of the extent to which a bird or other animal may feed on a given insect pest is of great importance, yet without the field work necessary to ascertain the extent of the depredations of such pests upon agricultural crops, it may be of little significance. The finding that most birds in a territory infested by grasshoppers feed extensively upon this crop destroyer may actually have little significance when the territory is large and the bird population small, yet appraised solely on laboratory analysis great benefit would be expected. The laboratory study, however, does show tendencies of a given species for good or harm, even though it largely fails in showing the general effect of a feeding habit. Only field work can show what is available. This information added to the laboratory data serves as a basis for anticipating what results can be expected under a given set of conditions. It, therefore, helps in outlining a course of action or in modifying agricultural procedure, or in following methods that will bring about an increase or decrease of the population of a given species of bird in a given area.

Combination of Field and Laboratory Research

Examples have been presented illustrating the fact that certain problems are best solved where emphasis is placed on either laboratory or field research, depending on the requirements of the particular problem in question. Most of them to some extent involve both sources of approach. Most problems in economic biology require for their solution a combination of both methods, and some seem difficult or impossible of solution without data obtained through this dual approach.

The need for both field and laboratory study may be illustrated by the following case, which resulted in unnecessary water-bird destruction and developed because of lack of a competent field study correlated with careful stomach examination. This occurred in North Dakota, where one of the two remaining nesting colonies of the double-crested cormorant in that State was destroyed by fishermen because it was believed that these birds were responsible for the disappearance of game fish from one of the largest lakes in that section. A careful field study proved that the disappearance of game fish was due to increased alkalinity of the water, which resulted from greatly lowered water levels and a consequent concentration of the alkaline salts. A detailed laboratory examination of a series of cormorant stomachs collected on that lake revealed that 75 percent of the food of the cormorants in that situation was made up of the axolotl stage of the tiger salamander (Ambystoma tigrinum), while 20 percent was composed of bullheads (Ameiurus sp.) from an adjacent prairie slough. The remaining 5 percent was made up of the five-spined stickleback (Eucalia inconstans) which was the sole species of fish capable of existing in the alkaline waters of the lake. This latter species is known to be destructive to the spawn of other fishes.

A study of the relation of predators to game birds and other animals is most accurately and expeditiously handled when field and laboratory studies are combined. Through field investigations the general trends of predation can be detected, but the degree to which specific predators may be charged therewith usually must be based largely on laboratory study. In such researches each method helps to interpret as well as to check the accuracy of the data obtained from the other.

In the study of predator and prey interrelationships the number of individuals of each species consumed in a given area over a period of time must be ascertained as well as the percentage that each species represents in the total bulk. These data reveal the seasonal requirements of the predators concerned and indicate in a general way how the various predators are likely to affect the interests of man. Experience has taught that an understanding of these broad trends in food habits is most accurately and economically obtained through examinations of either stomachs, pellets, gullet contents, droppings, or nest debris. To interpret the meaning and the reasons underlying predator food habits in any given area, there must, however, be available detailed data on all animal populations, not only of prey species but of predators as well. Intimate knowledge is needed of the environment and all the factors that affect predation. Among other things, for each situation there must be known the kinds and abundance of the species preyed upon, the cover present, the history of weather conditions, and the general health and vigor of the prey. The objective is to ascertain general food habit trends, but the ecological factors responsible for the ascendancy and decline of food items in predator diets are also of vital concern. To this end every known means of approach must be used that will develop a better understanding of the complicated problems of predator economics.

Only by such means can costly mistakes like the following be avoided: A field superintendent of an important upland game area in one of the Atlantic Coast States was killing every possible predator because he said his field observations over an extended period had shown him that all of them feed on quail. Stomach examination of a large series of captured "vermin" from this preserve revealed that practically all were feeding almost exclusively on field mice, which had become exceedingly abundant there. Predators were undoubtedly attracted because management practices, which consisted of the production of an abundant crop of food and cover, but included also extreme "vermin" control, had brought about a veritable mouse plague. The rodents became so abundant that they were a menace to the game supply, and the superintendent was forced to call for help in the control of this mouse infestation. If "vermin" control had not been carried to the extreme, the beneficial predators would have rendered service in the control of the field mice. A less biased field worker undoubtedly would have been more discriminating in his control procedure. The more expert game technicians are concluding that a predator population kept within reasonable bounds exerts a wholesome effect on wildlife by preventing reproduction of the less fit individuals, thereby maintaining a better quality in the wildlife and preventing the sickly or diseased from spreading their malady to healthy individuals.

The combination of laboratory and field research has contributed greatly toward finding important game foods that had previously been unrecognized. Because some of these can grow in special situations in which many commonly known foods cannot thrive, they are of tremendous importance in game management. While engaged in field research in coastal Connecticut, F. M. Uhler, of the Survey's scientific staff, observed black ducks feeding in certain habitats where acceptable food was thought to be scarce. A series of birds was collected and it was found from the stomach examination that they had been feeding primarily on saltmarsh acnida (Acnida cannabina). The birds seemed to be taking this in preference to feeding in adjacent fresh-water pools where good food was known to be abundant. In the tidal salt marshes but few plants of any known food value can endure the high salinity and fluctuating water levels; therefore this discovery should make it possible to increase immeasurably the waterfowl food supply in many coastal areas that are often nearly destitute of acceptable foods.

An additional example may be cited from the Mississippi Valley, where the water level fluctuation is so variable that the better duck food plants cannot survive. It was, therefore, an important discovery to find that rice cutgrass (Leersia oryzoides), hitherto unrecognized as being even of moderate worth as a duck food, was one of the most abundant and adaptable of plants in the area and a major food item in a good number of stomachs examined. Field work in a number of coastal States has given convincing evidence of the value of a semisubmerged aquatic, Scirpus nanus, as being of great value as a duck food in certain habitats. Other valuable food plants have similarly been found in different sections of the country. Some of these are of particular value because of their special adaptability or distribution and because they fill a niche unoccupied by other good waterfowl foods.

Laboratory Methods of Stomach Examination

The methods of laboratory research can only be suggested, as each must be adjusted to the particular problem in question. Only a broad outline of the method of stomach examination that has been found applicable to a great many species of birds can here be given (fig. 1). An earlier brief discussion of methods of stomach examination, prepared by W. L. McAtee (5), was published in the 1920 Yearbook of Agriculture. The stomach contents are all washed into a white-lined tray or pan, which aids in making the various items more visible. The larger particles may be picked out with forceps and placed on white blotters unless they need to be kept wet as an aid to proper identification. With a little practice much of the stomach or crop contents can be separated rapidly by mechanical means. By the use of this "wet method" lighter objects can be separated in piles by simple decantation if one carefully pours the contents of the pan on a fine grade of bolting cloth placed over a funnel. Because of the different densities or shapes of seeds of different species or of other items in the stomach much of the contents can be separated with little effort by various other mechanical devices, such as use of sieves of different meshes. Often there is much that can only be separated by the aid of a forceps and binocular microscope. Food items are usually placed on squares of white blotting paper. Some, perhaps most, items are more easily identified if they are permitted to dry, but such items as soft-bodied insects, crustaceans, green vegetable matter, or fruit are usually more easily identified if kept moist.

In preparing for examination the contents of some predator stomachs that contain considerable fatty foods, extensive use is made of hot water. This melts and washes off much of the excess fat or grease that may otherwise permeate the whole mass of the stomach content and obscure the identity of the diagnostic items. Note is made of the loss of bulk resulting, which is allocated to the items from which it appears the grease originated. This degreasing process is done with the aid of sieves of varied mesh. The contents are then placed in a drying oven, after which the various items are identified.

Identification of objects is facilitated by comparison with good collections of seeds, fruits, buds, insects, mollusks, and skeletons of birds, mammals, reptiles, amphibians, etc., and in fact examples of all classes of things ingested by birds. The Biological Survey naturally has representative reference collections of many groups of vertebrates and invertebrates, as well as of plants, seeds, tubers, etc., most commonly found in bird stomachs.

The number of specific items found in a single stomach varies greatly with different kinds of birds and under different conditions. As many as 65 species of items were found in a single stomach of an Arizona roadrunner, while the number of individual objects may extend almost indefinitely, depending of course on their size. The gizzard and gullet of one ruddy duck were estimated to contain as many as 200,000 oogonia of Chara. Within limits the kind of food consumed is largely in proportion to availability.

When the individual stomach examination is completed, the results are tabulated on a card and filed systematically. While the numbers of occurrences of individuals of each specific item in the stomach are recorded, the final results are expressed in percentage of volume. In general, bulk or volume percentages have been found to be much more reliable and more rapidly computed than those based on weight. Where the items in a stomach are of sufficient volume, the components are usually measured in a vial of appropriate size and computed on the basis of 100 percent. If, for example, the stomach contents consisted of but four items and measured 5, 10, 15, and 20 mm., respectively, they would obviously represent 10, 20, 30 and 40 percent, respectively, of the food content of the particular stomach. Gravel is frequently found, and among certain species of waterfowl it is usually greater both by weight and volume than the food. It is, therefore, first computed as a percentage of the total stomach content; then the food proper, after excluding the gravel, is computed also on the basis of 100 percent.

When a sufficient number of these cards have been accumulated for any species, each card containing a complete inventory of the bulk food percentages, with the number of items as mentioned above, the percentages of the principal food items for each month are calculated and the average of the season or year is figured. Where the number of stomachs is large enough to be representative, each month is considered as a unit. These are the figures quoted in official reports on the food of birds or other animals. Stomach cards are promptly indexed according to subject matter, so that information is available on the food items of each species studied and the known predator or feeder on any given animal or plant. Prompt report, therefore, can be given of the species of wildlife known to feed on any given insect, animal, or plant.

Since the establishment of this work in the Department of Agriculture in 1885, stomachs of some 600 species of birds representing thousands of individuals have been examined, and fairly complete laboratory studies have been made of perhaps 250 species. The magnitude of the problem is realized when it is remembered that more than 800 species, involving 1,420 separate species or subspecies of birds, have been recorded for the United States. There are also about 670 species of mammals, about 480 species of reptiles and amphibians, and approximately 600 fishes. Many of these have important economic bearings, and all can certainly be better understood and managed when full information is accumulated on their food habits and economic tendencies.

Even when a species of bird has once been studied in detail later investigations are often necessary because of changing agricultural conditions or shifts in agricultural practices, or because of new local problems. Upland game management, for example, demands that knowledge be had of the food habits of the quail or pheasant in every State or section. The relationship of a bobolink or a robin to agriculture depends largely upon the kinds of crops produced and the abundance of the birds in a given area. A change in either of these factors will naturally demand a change in the policy of protection or control with reference to these birds.

While the examination of stomachs has formed the basis of most of the laboratory food habit studies, fecal content and intestinal material have been used to some extent. The examination of scats, or droppings, is of great value as affording supplementary data on food preferences, as demonstrated by Murie (8), in a recently published paper on the food of coyotes in Jackson Hole, Wyo. For local or special studies, analysis of droppings may be of special merit and worthy of more extended application. They afford intensive study for a limited area or for a limited number of birds and possess the added virtue of sparing the lives of the individuals concerned. Fecal studies make it possible to follow trends in feeding habits of flocks of some species of birds throughout any season by making weekly or periodic collections from their roosting areas. This method is particularly applicable to upland game birds, but not readily applicable to many other species. Feces may be and usually are treated individually, or they may be analyzed in bulk as outlined by Dalke (1). Pellet examination has been extensively practiced in the Biological Survey and is of great value as a supplement to other methods. This method, however, is applicable only to a limited number of species, mostly birds of prey.

Errington (2) has reported a very worth-while technique in the study of raptor food habits. This consists essentially of forced regurgitation of gullet material of juvenile birds. Obviously this has the advantage of intensive study of individuals in a given area without injury to the birds. Furthermore the material is fresh and unaffected by digestive action, but on the other hand such methods can be employed for only a limited period. Much of the gullet study must of necessity represent field research.

Identification of food fragments in and around nests of raptors has been widely used as a supplement to other methods. Methods of field study of bird or animal relationships are about as diverse as the problems needing investigation. They must be applied to the particular problem under the particular set of conditions and circumstances attendant to that study. Accuracy of observation and of recording detailed data are about the only points in common to all field studies.

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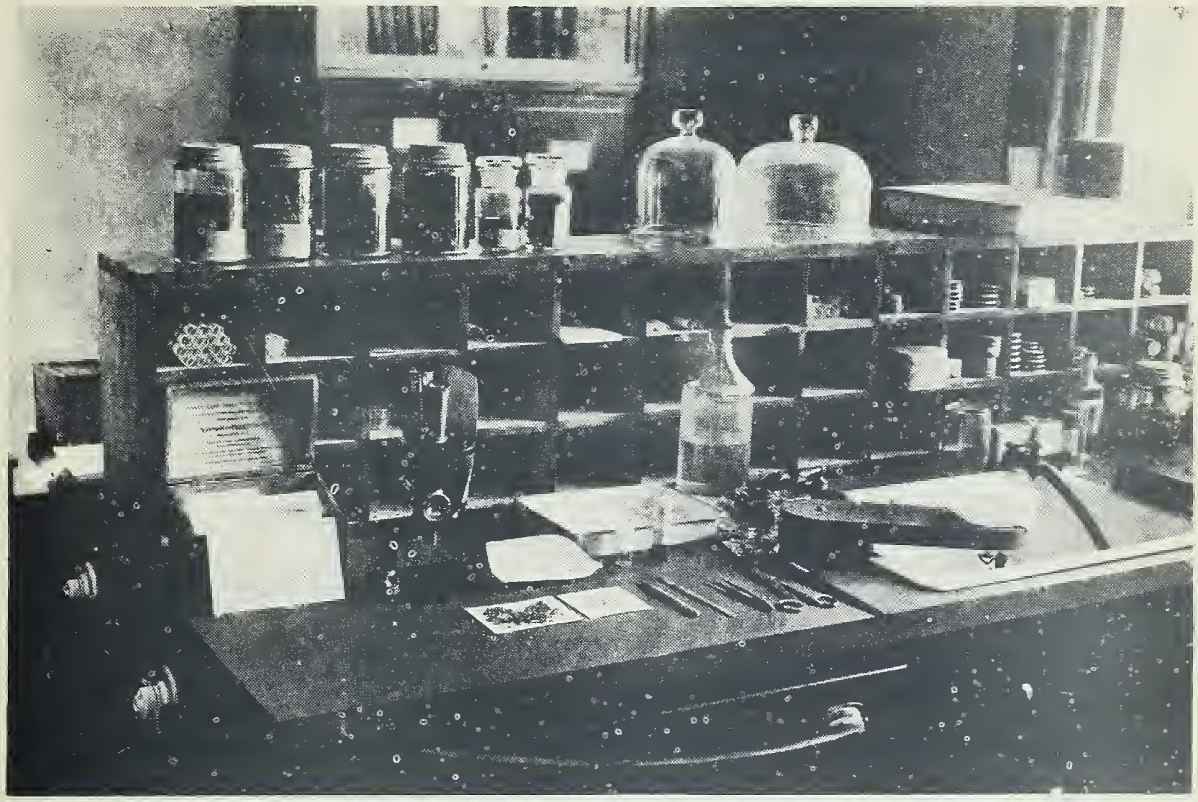

FIGURE 1.--Laboratory table equipped for stomach analyses. Equipment, in addition to the binocular microscope with various powers of objectives and eyepieces, includes stomach-analysis cards, filter, dissecting instruments, containers, preservatives, and other paraphernalia, as shown in the picture. Other compound microscopes and comparison microscopes are also frequently used.